FUDMA Journal of Agriculture and Agricultural Technology
ISSN: 2504-9496
Vol. 10 No. 2, June 2024: Pp.48-53

https://doi.org/10.33003/jaat.2024.1002.08

APPLICATION OF PRINCIPAL COMPONENT ANALYSIS TO QUALITY CHARACTERISTICS OF JAPANESE QUAIL EGGS IN MAIDUGURI, NORTHERN NIGERIA

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ABSTRACT

This research applied Principal Component Analysis to assess egg quality traits in Japanese quail reared in Maiduguri, Borno State, Nigeria. Two hundred and twenty (220)eggs collected from 20 week old quails were used. Data were collected on nine (9) egg quality traits included egg weight (EW), egg height(EH), egg width(WE), shell weight(SW), shell thickness(ST), albumen height(AH), yolk height(YH), Haugh Unit (HU) and albumen index(AI). 9.77 g, 2.99 cm, 2.42 cm, 0.90 g, 0.25 mm, 3.95 mm, 1.00 cm, 87.84% and 6.48% were the mean values obtained for the egg characteristics, respectively. Data were subjected to Principal Component Analysis using SPSS version 20.0. The three Principal components (PCs) extracted accounted for 72.14% of the total variance of the original nine egg qualities analyzed had 2.86, 2.62 and 1.01 as their Eigen values accounting for 31.78, 29.14 and 11.22% of the total variance, in that order. Moderate to large communalities (0.439-0.934) were an indication that a larger part of the variance was accounted for by the factor solution. PC 1 was characterized by high positive loadings on AH(0.957), HU(0.957) and AI(0.893); PC 2 described EW(0.621), EH(0.756), WE(0/762) with high positive loadings and YH(0.497) with moderate loading. PC 3 was characterized with high positive loadings on SW(0.754) and ST(0.878). The result thus indicated that PCs 1, 2 and 3are; descriptor of internal egg, egg size and egg shell qualities, respectively in Japanese quails.

Key words: Eigen value, Egg qualities, Communality, Japanese quail, Principal component.

INTRODUCTION

The relevance of quail in the poultry industry especially in such countries like Nigeria could not be overemphasized. The reason for this could be that attention has been diverted to quail meat and eggs making these important the same way chicken meat and eggs are important (Altinel *et al.*, 1996). Quail and pheasant share the same family, *phaseonidae* and were identified as migratory birds in Africa, Asia and Europe, the continents where they are obtainable (Adio *et al.*, 2019).Among the 'inbreed' sub-species of quail is Japanese quail, *Coturnix coturnix japonica* (Shim, 2004). According to Nasrollah (2008), these sub-species of quail were first discovered in Japan in the eight century. Although the potential of these birds was limited to cultural use (singing) in the eleventh century (Kayang *et al.*, 2004), later, findings revealed that quail are as important as domestic fowls in the production of meat and eggs. More interestingly, report has it that quails are most often raised for egg production (Ojediran *et al.*, 2022). They can lay up to 300 eggs in a year, although their performance is tied to the quality of feed (Ojediran *et al.*, 2022) and management provided. This is because, deterioration in animal welfare has direct link with stress accumulation. This consequently led to the development of diseases that can hinder production potentials (Pytlewski *et al.*, 2022) including that of egg production. Eggs are reckoned with on account of their biological and caloric values. Additionally, the overall significance quality and quantity of hatching eggs for continuity of flock and economic returns cannot be overemphasized. On this account, preference is given to eggs than meat inmost developing countries of the world (Anthony *et al.*, 2003; Kul and Saker, 2004; Sezer, 2007) including Nigeria. Egg is recognized as an economical animal protein source. Its characteristics are determined by its external and internal qualities which are mostly inter-correlated (Abdulraheem *et al.*, 2021).

In research related to animal genetics and breeding, enormous correlated traits are usually being encountered. Thus, data may become not only uneasy to analyze but also to interpret. Bottlenecks of this kind can easily be cared for by employing Principal Component Analysis (Abdi and Williams, 2010). This is done by transforming the correlated variable sets in to new sets which are not correlated. These are the Principal Components. The variables are arrayed in such a manner that larger part of the variations bared in all the original variables were contained in the first few sets (Jolliffe, 2002). Even though a number of multivariate analyses were identified, Principal Component Analysis, a unique technique in data analysis remains a widely adopted multivariate technique for a data set dimensionality reduction (Shaker and Aziz, 2017). This method has been used by many researchers to study characterization between breeds, strains and gene expression mostly in other farm animals species and chickens (Dorji *et al*., 2012; Udeh and Ogbu, 2011; Biswas *et al.*, 2008).Meanwhile, studies of this kind conducted on Japanese quail were scanty especially in the northeastern part of Nigeria. The objective of this study therefore was to apply Principal Component Analysis to assess egg quality characteristics of Japanese quail reared in Borno state, Nigeria.

MATERIALS AND METHODS

Experimental location

This work was carried out at the Livestock Teaching and Research Farm, University of Maiduguri, Maiduguri, Borno State, Northeast Nigeria. Maiduguri, the state capital is located on latitude 11^0 5' N, longitude 13^0 09' E at an altitude of 354 m above sea level. The area falls within the Sahelian region of West Africa which is characterized with varied climate and seasons. The environment is characterized with a short period of annual rainfall (3 to 4 months) with a mean of 645.9 mm. the dry period ranged between eight and nine months. The ambient temperatures are in the range of 35^0 - 45^0 C which are highest by the month of April and May. The relative humidity could be up to 45 % around August and as low as 5 % in December and January. Day length varies from 11 – 12 hours (Kellou, 2005).

Experimental birds

Two hundred and twenty (220) eggs were collected from one hundred and ten (110) 20 week old wild type Japanese quails and used for the study. Chicks were brooded for four weeks. Thereafter, sexing was done and female birds were housed, one bird per cage (40 x 30x30 cm wire mesh cages). They were given feed and water all times. They were fed formulated diet for containing 25% CP and 3000 Kcal ME/Kg for the six weeks. Thereafter, this was reduced to 24 % CP and 2750 Kcal ME/Kg. Their pens, feeders and drinkers were cleansed regularly. Birds were also given antibiotics at regular interval as a preventive measure against poultry diseases.

Data collection

The egg weight was measured with electronic scale (0.01 g sensitivity). Egg height and width were measured with a vernier caliper. The eggs were broken on a white tile after removing the internal components, egg shell was carefully washed to remove the remaining albumen and dried under air for twenty four hours. Egg shell weight was taken with an electronic scale (0.01 g sensitive). Shell thickness was taken as the average value of samples from sharp, blunt and equatorial parts. The measurements of yolk height and diameter, albumen length, width and height were taken using a pair of vernier calipers. Data generated were used to obtain additional internal egg quality characteristics using these formulae:

$$Albumenindex(\%) = albumenheight(mm)(albumenlenght(mm) + albumenwidth\ /2)X\ 100$$

$$Haughunit(HU) = 100\log(H + 7.57 - 1.7\ W^{0.37})$$

Where, H= albumen height (cm), W= egg weight (g)

Statistical analysis

Descriptive statistics of data was carried out using Statistical Package for Social Sciences (SPSS) V. 20 (2011). Phenotypic correlations among egg characteristics were calculated and the correlation matrix was generated and the primary data required for Principal Component Analysis using factor programme of the software. The Varimax criterion of the orthogonal rotation method was employed in the rotation of the factor matrix to enhance the interpretability of the principal components (Yakubu *et al.*, 2009). Factor loading was based on Eigen value of 1.00 and above, and the best descriptors were identified based on communality extraction factors closest to 1.00.

The component factor 1 was extracted using the following expression:

$$Y_1 = a_{j1}X_1 + a_{21}X_2 + \ \dots\dots\dots\ a_{P1}X_P$$

The next factor, Y_2 is formed such that its variance, $ƛ_2$ is the largest amount the remaining variance and that it is orthogonal to the first component factor. That is, $a'a_2$=0

The factors are extracted until limiting criteria encountered or until p components are formed. The weights used to create the principal components are the Eigen vectors of the characteristic equation:

(S- $ƛ_1$1)a $= 0$, or

(R- $ƛ_1$1)a $= 0$

Where, S is the covariance matrix and R is the correlation matrix. The $ƛ_1$are Eigen values, the variances of the components. Expression of the following equation gives the Eigen values: [S- $ƛ_1$1]=0 for $ƛ_1$

(Ukwu *et al.*, 2017).

The overall significance of the correlation matrices was tested using Bartlett's test of sphericity. Data suitability for Principal Component Analysis was further confirmed using Kaiser-Meyer-Olkin (KMO).

RESULTS AND DISCUSSION

The mean values for egg quality traits (Table 1) were 9.77±0.69 g, 2.99±0.015 cm, 2.42±0.011 cm, 0.90±0.01 g, 0.25±0.002 mm, 3.95±0.04 mm, 1.00±0.006 cm, 87.84±0.26% and 6.480.078% for Egg Weight (EW), Egg Height(EH), Egg Width(WE), Shell Weight(SW), Shell Thickness(ST), Albumen Height(AH), Yolk Height(YH), Haugh Unit (HU) and Albumen Index(AI), respectively. Co-efficient of variation for the external egg qualities were generally low (0.001-1.077) with egg weight having highest variability. Those of internal qualities were ranged low to high (0.009-14.64) with HU having the most variable co-efficient (14.64). The value for egg width observed in this study (2.42 cm) is in accordance with the value (24.81 mm) reported by (Shahin *et al.*, 2018). This was however lower than the value (25.65

mm) observed by (Shaker *et al.,* 2019)for the same trait both in quail. The difference in the reports of this study and that of other authors could be attributed to age of the birds, genotypes, environmental locations and or sample size.

Table 1: Descriptive Statistics of Japanese Quail Egg Quality Traits

Trait	N	Minimum	Maximum	Mean ± S.E	Co-efficient of variation
Egg Weight(g)	220	7.40	12.15	9.77±0.69	1.077
Egg Height(cm)	220	2.28	3.50	2.99±0.015	0.047
Egg Width (cm)	220	2.09	3.51	2.42±0.011	0.025
Shell Weight(g)	220	0.65	1.99	0.90±0.008	0,015
Shell Thickness(mm)	220	0.19	0.30	0.25±0.002	0.001
Albumen Height (mm)	220	2.00	5.47	3.95±0.043	0.407
Yolk Height(cm)	220	0.70	1.20	1.00±0.006	0.009
Haugh Unit(%)	220	77.30	96.50	87.84±0.257	14.64
Albumen Index(%)	220	3.20	9.01	6.40±0.073	1.162

N=Number of egg, S.E.= Standard Error

Correlation co-efficients

Co-efficient of correlations (Table 2) ranged low to high (0.02 to 0.94 and -0.03 to -0.19) for positive and negative estimates, respectively. The highest positive correlation (0.94) was observed between Haugh Unit and Albumen Height while the lowest limit (0.02) was between Yolk Height and Shell Thickness. Haugh Unit and Egg Height had the highest negative correlation (-0.19).On the other hand the, lowest estimate (-0.03) was between Haugh Unit and Shell Thickness. Egg Weight had strong positive correlations with the external traits (EW, HE, SW and ST) as well as YH but in contrary, the trait (Egg Weight) showed negative co-efficient with HU (-0.16). Similar to the relationships between Egg Weight and the eternal qualities, Albumen Index expressed strong positive relationships with other internal qualities (AH, YH and HU).

Strong positive correlations between EW and other external traits and YH as well as AI that had positive relationships with internal qualities suggest that the traits could be improved using egg weight in Japanese quail while Albumen index would be a good index to improve the internal qualities. Shafey *et al.* (2016) who observed significant positive correlations between egg weight and egg dimensions (egg width and egg length) though in chickens is in line with result of this study. Similar findings were related by Olawumi and Ogunlade (2008). Additionally, Farooq *et al.* (2001) reported high positive correlations for hatched chick's weight with egg height and width, this thus implies that egg weight, height and width would be good indicators for hatched chick's weight. Negative relationship, though not significant, between egg weight and Haugh Unit reported in this study should not be over-emphasized in selection programme as this suggests antagonistic effect. In general, positive correlations observed between the traits are proximate indications of pleiotropy (a situation when a single gene demonstrates multiple effects) and linkage (binding together of genes on the same chromosome) between the genes that control the two traits while the negative correlation suggests opposite action between the genes that control the traits. Low to high co-efficients of correlation observed in the study justifies possibility of improvement of both external and internal qualities of quail eggs. In general, the results of this study are in perfect agreement with the report of Sezer (2008) in Japanese quail.

Table 2: Co-efficient of Correlations between Egg Quality Characteristics in Japanese Quail

Trait	EH	WE	SW	ST	AH	YH	HU	AI
EW	0.57**	0.36**	0.53**	0.41**	0.09	0.28**	-0.16	-0.08
EH		0.45**	0.29**	0.21**	-0.03	0.11	-0.19**	-0.16*
WE			0.27**	0.18**	0.13	0.19	0.06	-0.06
SW				0.45**	0.09	0.18**	-0.04	-0.12
ST					0.07	0.02	-0.03	0.14
AH						0.36**	0.94**	0.80**
YH							0.31**	0.24**
HU								0.79**

EW=egg weight, EH=egg height, WE=egg width, SW=shell weight, ST=shell thickness, AH-albumen height, YH=yolk height, HU=Haugh Unit, AI=albumen index *Significant at P<0.05, **Significant at P<0.01

Principal Component Analysis (PCA)

The highly significant (0.000) Batlett's test of sphericity and adequate (0.655) Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy confirmed suitability of PCA data. Figure 1 presented Scree plot of Eigen values against their Principal Components. The extracted PCs accounted for 72.14% of the total variance of nine egg characteristic traits analyzed with 2.86, 2.62 and 1.01 Eigen values and31.78, 29.14 and 11.22% as percentage total variances, in that order (Table 3). These three PCs extracted had Eigen values that are greater than 1. This suggests that these three components have significant contributions to total variance so they have to be retained. However, the proportion of each of these components would determine their contribution to the total variance. This is because, the order of contribution to total variance decreases as the PC increases. This means that among the first three principal components, the first is greatest and third is least each of which is greater than the remaining PCs. In order words, PCs 4 to 9 had Eigen values less than 1 making them to make negligible contributions to the total variance. PC1, the component with the largest contribution to the total variance had high positive correlations on Albumen Height (0.957), Haugh Unit (0.957) and Albumen Index(0.893) suggesting PC1 to be a descriptor of internal egg qualities. PC2, the next component with highest contribution (after PC 1) to total variance was characterized by positive loadings on Egg Weight(0.621), Egg Height(0.756), Egg Width(0.762) and a moderate loading on Yolk Height(0.497). PC2 therefore is a descriptor of egg size qualities as they relate to yolk height. PC3as the least in contribution to total variance, though with significant contribution to total variance, had high positive correlations on Shell Weight (0.754) and Shell Thickness (0.878) indicating that PC3 could be regarded as a descriptor of egg shell qualities. Ukwu *et al.* (2013) who reported PC1 as a descriptor of internal egg qualities, PC2describedegg external traitswhilePC3described shell characteristics of egg in Isa Brown chickens correlates well with the findings of this study. This thus implies that loadings of principal factors in quail eggs qualities are similar to loadings for eggs quality traits in other galliforms especially domestic fowl (chicken). In their findings however, Shahin *et al.*(2018)and Shaker *et al.*(2019) who extracted only two factors probably because the Eigen values of other factors were less than 1, observed that PC1 had positive loadings on external egg qualities. This thus contradicts the result of this study. The variation in the results may be connected with the variation in number egg traits examined and or the age of birds at time of egg collection.

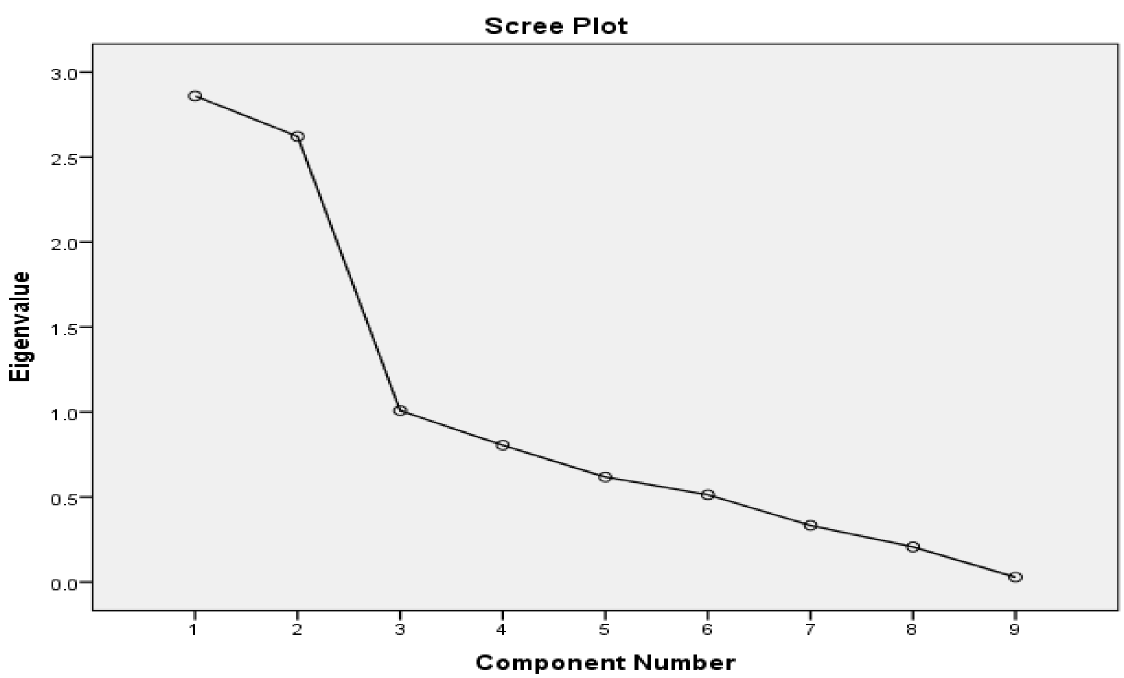

Figure 1: Scree plot of Eigen Values against their PCs

Table 3: Rotated Component Matrix, Eigen Values and Percentage of Total Variance of Egg Quality Characteristics

	Component			
Trait	**1**	**2**	**3**	**Communality**
Egg Weight(g)	-0.049	0.621	0.575	0.718
Egg Height(cm)	-0.178	0.756	0.221	0.651
Egg Width (cm)	0.045	0.762	0.080	0.589
Shell Weight(g)	-0.004	0.296	0.754	0.656
Shell Thickness(mm)	0.026	-0.010	0.878	0.771
Albumen Height (mm)	0.957	0.105	0.085	0.934
Yolk Height(cm)	0.438	0.497	-0.022	0.439
Haugh Unit (%)	0.957	-0.044	-0.060	0.922
Albumen Index (%)	0.893	-0.117	-0.015	0.812
Eigen value	3.123	2.894	1.548	
% of total variance	26.027	24.114	12.902	
% cumulative	26.027	50.141	63.043	

CONCLUSIONS

PC1describedthe internal quality characteristics of quail egg, PC 2 described egg size qualities in relation to yolk height and PC3 could be regarded as a descriptor of egg shell qualities. It indicated that egg weight cold be predicted using albumen, yolk and shell qualities, in the order of loadings. The extracted three factors could be used as guides to establish interdependence in the original nine quality traits of Japanese quail egg. Hence, using the three orthogonal egg traits factors (Principal components) extracted from PCA could be more reliable in predicting egg characteristics than the original inter-correlated egg qualities. This could be essential elements in an effective breeding scheme to improve Japanese quail egg characteristic traits especially in the northeastern region of this country. It is recommended that the internal quality traits of egg can be used to improve and predict egg weight in Japanese quail.

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